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A DEMOGRAPHIC SURVEY OF BRYANT'S WOODRAT IN A DISTURBED HABITAT

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Abstract:
We conducted a demographic survey of Bryant's Woodrat (*Neotoma bryanti*) in an anthropogenically disturbed habitat in the Mojave Desert of southern California, USA from January, 2019 to July, 2020. We hypothesized that Bryant's woodrat would show higher individual turnover than similar species occurring in more pristine habitat. This hypothesis was not supported with the use of capture-recapture modeling (Jolly-Seber method) that showed that this population had relatively low individual turnover across sampling dates, combined with a high population density of several hundred animals per km^2. Males and females did not significantly differ in average apparent survival rates, but did show sexual size dimorphism. These results show that this population is presently stable, however, further research on this population is needed to assess if there are any long-term consequences caused by the anthropogenic disturbances.

Introduction:
Bryant's woodrat (*Neotoma bryanti*) is a small herbivorous rodent within the family Cricetidae, distributed along the coast of California east of San Francisco, USA, south to the peninsular tip of Baja Sur, MX (Patton et al. 2007). Woodrats serve as keystone species through their nesting behavior that promotes arthropod biodiversity, and by providing nitrogen rich excrement which promotes the growth of local vegetation (Whitford and Steinberger 2010). Bryant's woodrat occur in coastal, chapparal, and desert scrub habitat, and are generalist foragers (Patton et al. 2007). The IUCN Redlist presently considers this species as 'least concern' but notes many populations are declining due to habitat loss (Castro-Arellano and McCay 2019). Despite this IUCN Redlist description, there is little empirical evidence that Bryant's woodrat occurring in disturbed habitat are experiencing population declines. The aim of this study was to survey the population dynamics of Bryant's woodrat occurring in disturbed habitat to generate empirical data on this species' response to habitat disturbance. We hypothesized that Bryant's woodrat occurring in disturbed habitat would experience higher turnover than similar species occurring in less disturbed habitat. This informative data will provide insight into how anthropogenic disturbances could be influencing the demographics of this species and similar mammalian herbivores.

Study site: The "Whitewater" site is located in the Mojave Desert in Morongo Valley, San Bernardino County, CA, and is situated between the San Bernardino and San Jacinto mountain ranges (Fig. 1A) in a xeric habitat. The site is composed of desert shrublands and is dominated by creosote bush (*Larrea tridentata*) and white rhatany (*Krameria bicolor*), with scattered California sagebrush (*Artemisia californica*), Brittlebush (*Encelia farinosa*), and ephedra (*Ephedra californica*). The habitat is fragmented by highways, roadways, houses, wind turbines, power lines, oil pipelines, and it is used frequently as a dumping ground for human trash. Bryant's woodrat at this site are likely dispersal limited due to the natural mountain boundaries to the north and south, and urban boundaries to the west.

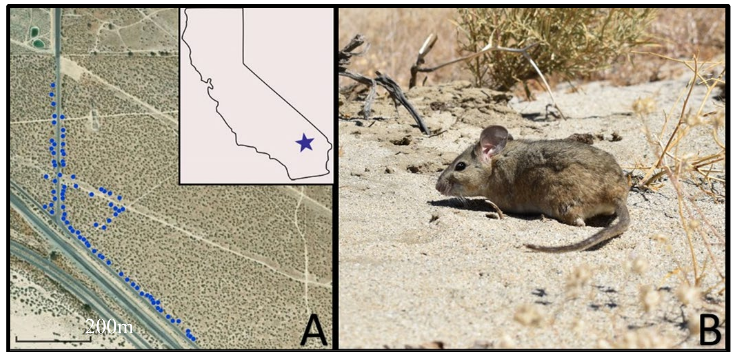

Figure 1. A) Google Earth™ Satellite imagery of the Whitewater trap site in Morongo Valley, CA. Blue dots indicate woodrat trapping localities. B) An adult Bryant's woodrat.

Methods:

Animal trapping: We trapped woodrats every 8-16 weeks from January 2019 to July 2020 within Morongo Valley, CA, for a total of 8 trips. We live-captured woodrats using Sherman traps placed in pairs along apparent stick nests across 3 separate 400-600m transects (Fig. 1A), with a total trapping area of ~20 ha. Traps were baited with a mixture of oats and creosote bush clippings, set at sunset, checked at sunrise and relocated if no woodrat was captured after 4 trap nights. Once captured, animals were weighed, sexed, measured, and given a uniquely marked ear tag. Animals were then released at their capture location.

Demographic analyses: We used a Jolly-Seber open capture-recapture model in program JOLLY (Pollock et al. 1990) to compute apparent survival rates (φ), capture probability (*P*), population size (N), and recruitment (β) using the recapture histories of each individual over the course of the study. We corrected the time intervals in the model to reflect the actual temporal spacing between sampling dates (t_1 = 8 weeks; t_2 = 16 weeks) and assessed the fit of the model with a goodness of fit test. We used age and sex as intrinsic covariates in the model. We used the mean estimated population size (N) and area of the trapping site to estimate population density.

Results:

Field observations: There was sexual dimorphism in body size of Bryant's woodrat at Whitewater where males are 18.4% larger than females (t-test; $t_{145} = -6.0$, $p < 0.01$; Table 1). Additionally, we found that the average mass of adult individuals was lower in January compared to March and July of the same year (ANOVA: $F_{262;6} = 4.24$; $p = 0.004$; Supplemental Fig. 1). Based on the presence of lactating females and scrotal males, Bryant's woodrat was likely reproductively active at Whitewater from January to early May. Given the generation time, there is potential for multiple litters within the same reproductive season.

Table 1: Jolly-Seber open mark-recapture model results and average mass of Bryant's woodrat January, 2019 to July, 2020 across seven trapping trips. Model time interval = eight weeks.

Group:	φ average (SE)	*P* average (SE)	N average (SE)	β average (SE)	Average adult mass (g); (SD)
Male	0.71 (0.07)	0.76 (0.08)	27 (2.65)	12 (1.82)	174 (32)
Female	0.72 (0.05)	0.71 (0.08)	29 (2.77)	11 (1.40)	147 (25)
All	0.70 (0.02)	0.74 (0.06)	55 (3.61)	23 (2.20)	161 (32)

φ = apparent survival; *P* = capture probability; N = population size; β = recruitment, SE = standard error; SD = standard deviation.

Jolly-Seber model results: Bryant's woodrat at Whitewater, CA had an average 8-week apparent survival rate of 0.70 across 1.5 years of sampling (Table 1). Both sexes showed similar average survival rates (males = 0.71; females = 0.72). In other words, both sexes of woodrats had approximately a 70% chance of surviving from one capture session to the next. However, males had lower survival from March, 2019 to May, 2019 compared to females (Fig. 2). Overall, these results do not support our hypothesis as there was low turnover of individuals between sampling dates. This population showed stable recruitment (β) of an estimated 23 individuals on average between sampling trips, and an estimated population size (N) of 55 individuals within a 20ha trapping area (Table 1). Assuming a consistent occupancy within this habitat, we estimate there is a high population density of Bryant's woodrat at Whitewater of ~275 individuals/km^2.

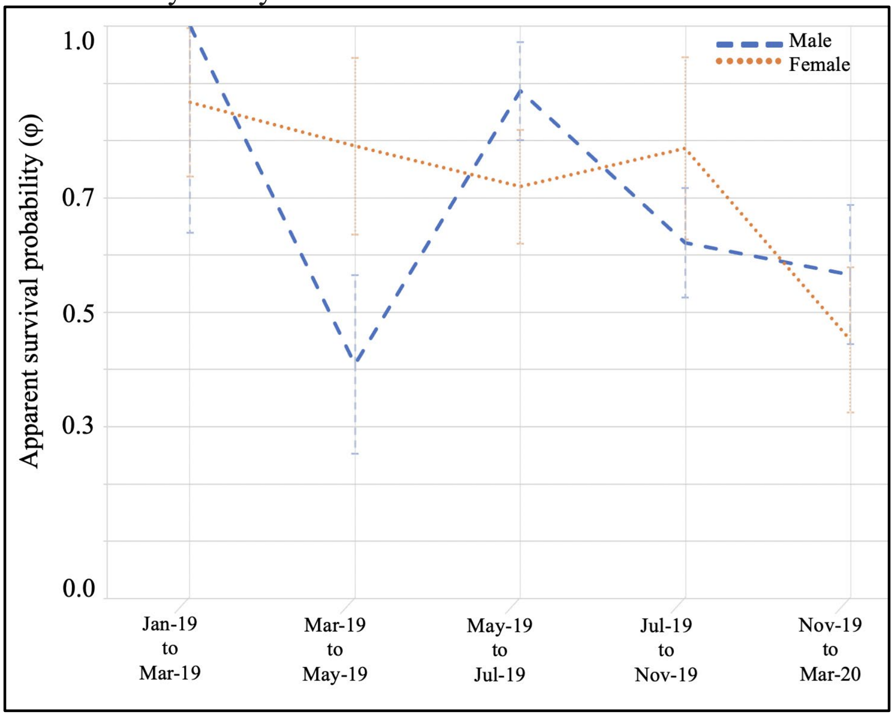

Figure 2. Apparent survival of Bryant's woodrat at Morongo Valley, CA, colored by sex. Error bars represent standard error.

Discussion:

Bryant's woodrat in a disturbed Mojave habitat demonstrated high population stability as evidenced by low individual turnover and high population density across 1.5 years of sampling. Additionally, a majority of individuals are surviving at this site into reproductive maturity, typically between 6 to 9 months of age (Matocq 2004), and are potentially having multiple successful reproductive events per year. The apparent survival of adults was consistent with Big-eared woodrat (*N. macrotis)* occurring in similarly disturbed pine forest habitat, and in pristine riparian habitat (Lee and Teitje 2005; Hunter et al. 2017). An informative future study could compare the results of this study to that of Bryant's woodrat survival in a pristine Mojave Desert habitat. This would control for species effects and climate, but identify any effects of food availability, predation pressures, and anthropogenic disturbances on the survival of Bryant's woodrat. The sharp decline in apparent survival in male woodrats from March to May, 2019 was likely the result of dispersal rather than increased predation, disease, or some other mortality event, as female woodrats maintained high apparent survival during this same period. Male woodrats are known to disperse much further than females when looking for a nesting site, and can travel several kilometers a night when searching for a mate. For this reason, females are typically used in open marked recapture models to represent population averages of apparent survival (Matocq 2004).

Reduced predation pressure could be the underlying cause of the high apparent survival of Bryant's woodrat at this site. Whitewater is highly fragmented by roadways and is located directly beside the highly trafficked highways, which may deter the presence of mammalian predators such as coyotes and foxes (Fahrig and Rytwinski 2009). Additionally, the noise pollution caused by the site's proximity to the city of Palm Springs and highways may reduce the foraging efficiency of avian predators such as owls (Senzaki et al. 2016). Bryant's woodrat predominately feed upon creosote bush and white rhatany at this site (Klure; unpublished data), which are highly abundant plant species that are resilient to the anthropogenic disturbances at Whitewater.

Overall, these data revealed that not all anthropogenic disturbances have similar impacts on different mammalian species. Small prey species such as woodrats may show resilience to anthropogenic disturbances that do not reduce the abundance of their dietary items, and may experience a reduction in predation pressure caused by disturbances that deter the presence of some predator species.

Although this population of woodrats was found to have low individual turnover and a high population density while occurring in a highly disturbed habitat, this may be a short-term phenomenon. It is possible the roadways, cities, and highways surrounding this site may act as a barrier against gene flow from neighboring populations, which could lead to a reduction in genetic diversity. For this reason, our lab will be screening hundreds of Bryant's woodrat individuals from Whitewater and at surrounding populations in the Morongo Valley Basin to address questions of genetic connectivity, genetic diversity, and inbreeding rates of woodrats occurring in disturbed habitats using double-digest restriction enzyme associated DNA sequencing (ddRADseq; Peterson et al. 2012).

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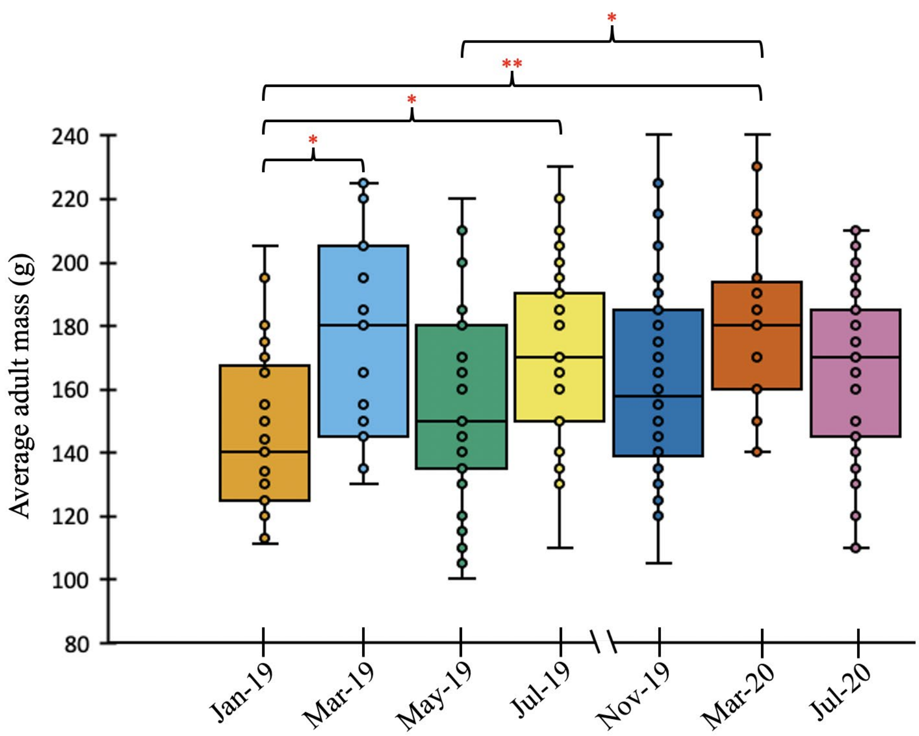
Supplemental figures:



Supplemental Figure 1. Average adult body mass of Bryant's woodrat across the seven sampling dates. Asterisks indicate significant differences between groups (ANOVA: $F_{262:6} = 4.24$; $p < 0.01$). * = $p < 0.05$; ** = $p < 0.01$.